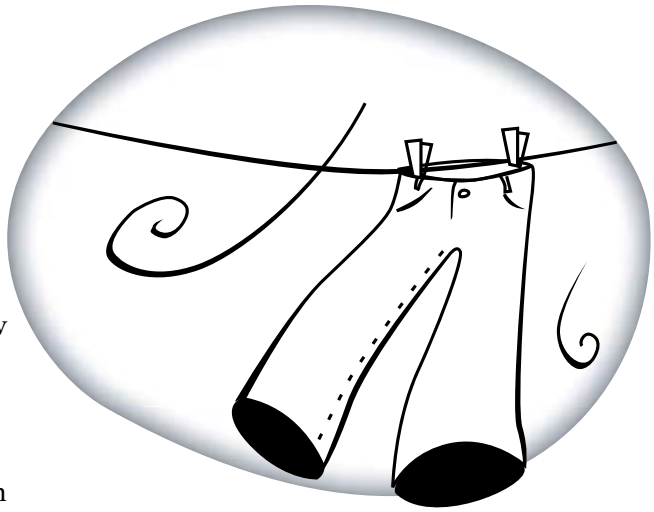
# Wet Jeans

Sam washed his favorite pair of jeans. He hung the wet jeans on a clothesline outside. An hour later the jeans were dry.

Circle the answer that best describes what happened to the water that was in the wet jeans *an hour later*.



**A** It soaked into the ground.

**B** It disappeared and no longer exists.

**C** It is in the air in an invisible form.

**D** It moved up to the clouds.

**E** It chemically changed into a new substance.

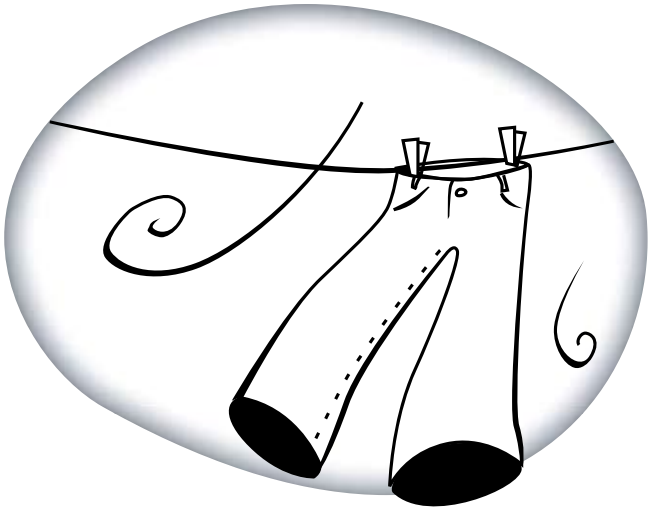
**F** It went up to the Sun.

**G** It broke down into atoms of hydrogen and oxygen.

Describe your thinking. Provide an explanation for your answer.

# Wet Jeans

## Teacher Notes



### Purpose

The purpose of this assessment probe is to elicit students' ideas about where water goes right after it evaporates. It is designed to determine if students recognize that water exists in the air around us in the form of water vapor. Since students often use the terminology of the water cycle with little understanding of actual phenomena, this probe intentionally avoids use of technical words such as *evaporation* and *water vapor* in order to examine how students think about evaporation and the water cycle.

### Related Concepts

water cycle, evaporation

### Explanation

The best response is C—it is in the air in an invisible form. This invisible form is called water vapor. Contrary to what is often inadvertently depicted in water cycle diagrams, water does not immediately go up to the clouds or Sun as described in distracters D and F. It rises and exists in the air around us as an invisible gas. Humid weather is an example of water in the air. The wet dew on the grass in the morning or condensation of water on the outside of a cold beverage glass confirms that water exists in the air around us. Eventually some water molecules do rise high in the atmosphere and form clouds. The idea in distracter A that the water from the jeans may have soaked into the ground can be challenged with the observation that water is not dripping off of the wet jeans and landing on the ground. The principle of conservation of matter refutes distracter B.

Matter cannot be destroyed. A change in state from a liquid to a gas is a physical change. The substances, liquid water and water vapor, are still chemically the same. They do not change into a new substance or break down into hydrogen and oxygen atoms as described in distracters E and G.

## Curricular and Instructional Considerations

### Elementary Students

Younger students' opportunities to learn focus primarily on phenomena they can observe, such as the notion that water in an open container will eventually disappear. As students progress to upper elementary grades they begin to conduct investigations to explain the observations they made in earlier grades. An important idea to develop before they move on to middle school is the notion that when water disappears it is in the air in the form of invisible water vapor. This is a grade-level expectation in national standards that is often overlooked when teaching the water cycle and emphasizing terminology without understanding. In addition students must have opportunities to learn that air is a substance rather than existing as "nothing." This probe can be used to determine what students' ideas are prior to designing instruction that will help them discover that water goes into the air after it evaporates.

### Middle School Students

The water cycle is of profound importance for middle school students' understanding of Earth systems. However, before the idea of the cyclic nature of water is developed, teachers need to be sure students understand what happens to water after a change in state. Many middle school students use the term *evaporation* without completely understanding where the water goes after it evaporates. Representations of the water cycle in textbooks that show an arrow pointing up to a cloud may perpetuate the idea that evaporated water immediately goes up to the clouds or the Sun. Middle school is the time when students begin to develop a particulate model of what happens to water when it evaporates. This probe is useful in determining whether students have an accurate conception of where water goes after it evaporates from a surface, prior to developing the more sophisticated ideas about cycling of water.

### High School Students

At this level students develop more sophisticated ideas about particulate models and cycling of matter, such as water, through ecosystems. However, do not assume that students have a correct conception of simpler ideas such as evaporation. This probe is useful in determining whether students have progressed beyond their preconceptions about where water goes after it evaporates before more complex ideas are taught in high school Earth science.

### Administering the Probe

If the context of wet laundry on a clothesline is

unfamiliar to students, use a more familiar example such as a puddle drying up after it rains (although this may increase the number of responses that the water soaks into the ground, which points out a strong alternative conception). Or, hang a moist paper towel up in the classroom, which will dry fairly quickly without dripping. This can be combined with students actually observing the phenomenon and then asking the question, Where is the water now? You may wish to ask students to draw a picture to help explain their thinking. The picture helps reveal whether students' thinking is influenced by the diagrams they have seen of the water cycle.

## Related Ideas in *National Science Education Standards* (NRC 1996)

### K–4 Properties of Objects and Materials

★ Materials can exist in different states: solid, liquid, and gas. Some materials, such as water, can be changed from one state to another by heating or cooling.

### 5–8 Structure of the Earth System

- Water, which covers the majority of the Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the Earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.

## Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993)

### K–2 The Earth

- Water left in an open container disappears, but water in a closed container does not disappear.

### 3–5 The Earth

★ When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.

### 6–8 The Earth

- Water evaporates from the surface of the Earth, rises and cools, condenses into rain or snow, and falls again to the surface.

## Related Research

- Research has shown that students seem to go through a series of stages before they fully understand evaporation as a process that converts water to an invisible form. At first they may seem to think that when water evaporates, it simply ceases to exist. In the next stage they may think it changes location but that it changes into some other form we can perceive, such as fog, steam, or droplets. Fifth grade is about the time that students can accept air as the location of evaporating water if they have had special instruction that targets this idea (AAAS 1993).

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

- Students' scientific concept of evaporation appears to be dependent on three notions: (1) conservation of matter, (2) the idea of atoms or molecules, and (3) the idea that air contains particles we cannot see. Ages 12–14 are the time when students are apt to link these notions (Driver et al. 1994).
- A study by Barr and Travis (1991) found that students' understanding of evaporation in a boiling context may precede their understanding of evaporation of water from surfaces. In the sample in that study, 70% of six- to eight-year-old students understood that there was vapor coming out of water when it boiled. They understood that the water was going somewhere as the amount decreased from the container and that the vapor was made of water. However, the same children thought that when a solid, wet object dried, the water simply disappeared or it went into the object (Driver et al. 1994).

## Suggestions for Instruction and Assessment

- Elementary students should have multiple experiences in observing how water disappears from various surfaces and open containers. Older elementary students should be challenged to think about where the water goes immediately after it disappears and where it may eventually end up.
- Elementary students learn that water in an open container disappears. This is a grade-level expectation in national standards. However, be sure students understand that the word *disappear* does not mean the water no longer exists but rather that it exists but we can no longer see it. Use an analogy such as a student leaving the room. We can say the student "disappeared" because we can no longer see the student. However, the student still exists somewhere. It is important to be careful how we use words such as *disappear*. Students may develop incorrect notions of conservation of matter in the context of the water cycle if teachers are not careful with the words they use to describe phenomena.
- Elementary students need concrete experiences to understand what happens to water during a change in state before developing the more sophisticated idea of a cycle.
- Teach students what happens to water before introducing terminology like *evaporation*. Many students will use the word *evaporation* without understanding where water actually goes. Students need inquiry-based experiences to discover for themselves that water is in the air around them before using the terminology. The careful wording in *Benchmarks* (AAAS 1993) affirms this notion of developing some ideas before using terminology. Once students have the idea, the term can be introduced with meaning.
- Be aware that many textbook representations may contribute to the idea that evaporated water immediately goes up to the clouds or the Sun. Many representations show upward arrows pointing to the clouds or Sun that may influence students'

thinking about the phenomenon. Explicitly point out the flaw in these representations to students or challenge students to examine representations and point out possible flaws.

- Consider combining an outdoor example with an indoor example. The latter may help students change their thinking that the water went immediately up to the Sun or clouds. For example, a wet paper towel that dries in the classroom during a class period may elicit the question, "Where is the water now?" The confines of the room may help students change their model about where the water goes.
- Challenge older students to come up with an explanation for why wet laundry takes much longer to dry on a humid day. Challenge students to use a particulate model to explain their thinking.
- Some students may have used a humidifier at home or put out pans of water to increase humidity in the air for their houseplants. Use these examples to develop the idea that water molecules are in the air, even though we cannot see them.
- Teaching about evaporation in the water cycle involves several interrelated ideas that should be combined in instruction. These ideas include conservation of matter, phase change, and composition and nature of air. It is particularly important that students accept the idea of air being a substance that is made up of matter we cannot see.
- Many assessment items use water cycle diagrams to determine students' ideas about the water cycle. Students may answer questions correctly related to the water cycle yet fail to understand the idea that water may exist in the air that surrounds us. Use a variety of items that combine assessment of ideas related to components of the water cycle with assessment of cyclic ideas.

## Related NSTA Science Store Publications and NSTA Journal Articles

American Association for the Advancement of Science (AAAS). 2001. *Atlas of science literacy.* (See "States of Matter," pp. 58–59.) New York: Oxford University Press.

Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas.* London and New York: RoutledgeFalmer.

Gilbert, S. W., and S. W. Ireton. 2003. *Understanding models in earth and space science.* Arlington, VA: NSTA Press.

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

Smith, M., and J. Southard. 2002. Water is all around you. *Science Scope* (Oct.): 32–35.

### Related Curriculum Topic Study Guides

(Keeley 2005)
"Water Cycle"
"States of Matter"

## References

American Association for the Advancement of Sci-

ence (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

Barr, V., and A. Travis. 1991. Children's views concerning phase changes. *Journal of Research in Science Teaching* 28 (4): 363–382.

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